be folly to assert that perfection had been attained or progress could not still be made. With better knowledge of insanity on the part of the people at large, quickened legislative interest, and larger facilities in the command of officers of asylums, a new atmosphere may be brought to pervade the abodes of these unfortunates; but these must all work together, and can accomplish little if at war.

A movement for the social and moral deliverance of the insane, similar to the physical emancipation effected by Pinel when he struck off the chains of the madmen in the Bicétre, seems to be gathering force from all sides. Iron manacles were then considered appropriate for lunatics, and the great liberator was asked if he had not himself gone mad in making so wild an experiment.

To-day, perpetual enchainment in a living tomb is no longer tolerated, but fetters of the spirit are equally odious to our age, and the philanthropy of the time will not rest until it sees the asylum for the insane deprived of its many remaining imperfections.

ART. VI.—RAPIDITY OF TRANSMISSION OF NERVE-FORCE IN NORMAL AND STRETCHED NERVES—EXTRA-POLAR KATELECTROTONUS.

By Isaac Ott, M. D.

THE ability to measure the rapidity of nerve-force was thought to be impossible, but Helmholtz, by means of the galvanometer, solved the question. The galvanometer was used to measure the small interval of time. He afterwards turned his attention to the graphic method of measuring the time involved. His results on the nerves of frogs were, that between 11° and 21° C. the rapidity varied between 24.6 and 38.4 metres, the most probable mean as 26.4 metres per second. Low temperature reduces the rate of transmission. In my experiments I employed a Marey-Foucault regulator, a glass disc on the vertical axis which revolved with great rapidity, and on the glass a piece of smoked paper was fastened. A bridge of two pieces of light strips of metal was made, and mounted on a piece of hard rubber. On one of the wings of the Foucault regulator was placed a projection-point, which, when the expansion reached a certain point, knocked over the bridge and opened the battery current in the primary spiral of Dubois-Reymonds induction apparatus. This generates an opening induction-current in the secondary spiral, which irritates the nerve causing contraction of the muscle. The excitation is sent to any part of the nerve by means of Pohl's commutator and Rosenthal's rheophoric box, which is a gutta-percha trough, having wires traversing it at intervals, and covered with a glass plate; its bottom being covered with moistened blotting paper. On these wires the sciatic nerve of a frog is laid, and kept moist. The gastrocnemius muscle is attached to the lever of a Marey's myograph, which registers the contraction on the smoked disc. Now as the current is only broken when the fan of the regulator expands to a certain point, the same rapidity of the disc is always obtained for each experiment, and the current is always broken at the same point. It is possible that there may be a slight variation of rapidity, but I think it can be overlooked. The time was obtained by allowing a tuning-fork to register one two-hundred-and-fiftieth of a second. (In Fig. 1 I give a result). The inmost circle shows where the muscle began to contract when the irritation was made near the muscle. The outer circle shows where the muscle contracted when the nerve was irritated four centimetres up the nerve from the preceding point of irritation. The zigzag curve gives the curves of the tuning-fork, each swell being 1-250th of a second. Now radii are drawn from the centre of the disc through the points of departure of the muscle-curves, and prolonged to the tuning-fork curve. Now the difference between the radii will be equal, as is seen to 1-500th of a second for four centimetres of nerve, that is twenty metres per second. These experiments were made at a temperature between 9° and 10° C. In an examination of a considerable number of experiments, I found the rate of transmission in the motor nerve of the frog was between twenty and thirty metres per second. Care was taken to ascertain that the latent period of muscular contraction was unchanged during the experiment. When the rate of movement of nerve-force was compared with that of electricity, it was found insignificantly slow, electricity moving 464 million metres per second, and light 300 million metres in the same time. This slow rate of nerve-force is usually one of the great arguments against the identity of electricity and nerve-force. Whilst I do not believe in their identity, it is not a very strong argument, as there are certain agents through which electricity will not pass at all. Nerve-force must as yet be considered among one of the things called vital, due to some *Great Proximate Cause.* That electricity and nerve-force have similar properties, I shall show. Faraday unveiled that when a wire is subject to either volta-electric or magneto-electric induction

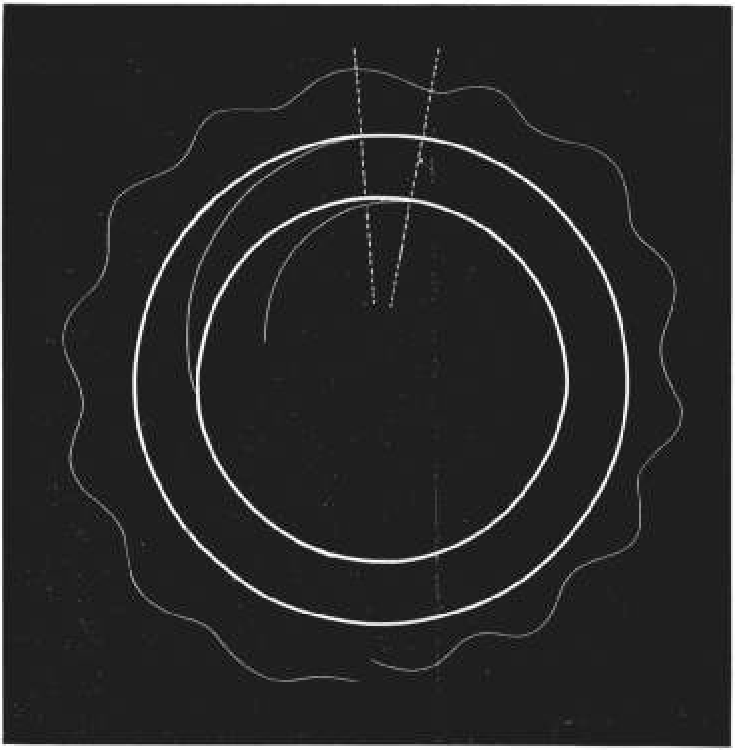

Fig. 1.

it resists the formation of an electrical current in it, whereas, in its ordinary condition, such a current would be produced. He supposed this due to a polar arrangement of the molecules of the wire, and called it electrotonus. Now Dubois found that the galvanic current, when passed through a nerve, offered a resistance to the animal current of a frog's nerve. After Faraday, DuBois called this electrotonus of the nerve, and considered it due to a polar arrangement of the nerve-molecules. Further, electrotonus offers a great impediment to the rate of conduction of nerve-force. Having studied the rate of transmission of nerve-force in normal nerves, I made some researches on the rate in stretched nerves; stretching nerves having become a recognized method of treatment in some nervous affections, such as sciatica. Here the difference between the curves of origin of muscular contraction on the same line were measured, and conjoined with that found after stretching the nerve.

Experiment 1. Nerve-muscle preparation. Temperature, 9° .2 C.

10.45 A. M. Normal distance between origin of curves 4 m. millimetres.

10.46 A. M. Nerve stretched from 3 centimetres to 4 centimetres.

10.48 A. M. Distance between origin of curves, 7 m.

Experiment 2. Nerve-muscle preparation. Temperature, 9° .2 C.

10 A. M. Normal distance between origin of curves, 4 millimetres.

10.1 A. M. Nerve stretched about 2 centimetres.

10.2 A. M. Distance between curve's origin, 5 millimetres.

10.3 A. M. Extra-polar katelectrotonus of nerve near the exciting electrodes at greatest distance from the muscle.

10.6 A. M. Distance between curves, 6 millimetres.

Experiment 3. Nerve-muscle preparation. Temperature, 10° .4 C.

11.40 A. M. Normal distance between origin of curves, 3 millimetres.

11.41 A. M. Nerve stretched from 3 centimetres to about 4.5 centimetres.

11.43 A. M. Distance between origin of curves, 4 millimetres.

11.44 A. M. Extra-polar katelectrotonus.

11.45 A. M. Distance between curve's origin, 9 millimetres.

As will be seen by an examination of the above experiments, stretching lowers the rate of transmission of nerve-force in nerves. If there was any relation between the amount of stretching and rate of conductivity it was not determined. In studying the effect of extra polar katelectrotonus, I used two Bunsen cells of considerable size, and the extent of nerve traversed was about three millimetres. When a galvanic current traverses a nerve it separates it into two zones; the part about the negative pole is called katelectrotonus, and that part about the positive pole anelectrotonus. Von Bezold found that extra polar katelectrotonus reduced the rate of movement of nerve-force. Like him, I used strong currents in the study of extra polar katelectrotonus. As to the effect of weak currents, I cannot speak. The following expresses the conclusions at which I have arrived:

1. The rapidity of transmission of nerve-force, at the temperature of about 10 C., is between twenty to thirty metres per second.
2. That stretching a nerve lowers the rate of movement of nerve-force.
3. That strong currents causing extra polar katelectrotonus, as in normal nerves, retard the movement of nerve-force.